



Eijkelkamp Smart Lysimeters

User manual (original instructions)



Meet the difference

Contents

1. Information on this manual	3
2. Introduction	3
3. Types and accessories	4
4. Technical specifications	4
5. Safety instructions.....	5
6. Regular inspection and field maintenance.....	5
6.1 Typical maintenance actions.....	6
6.2 Checking settings and actual values	7
6.3 Main menu	9
6.4 Measurements menu.....	9
6.5 Installation menu.....	10
6.6 Factory menu.....	12
6.7 Calibration menu.....	14
6.8 Dismantle / environment/ disposal of waste.....	14
7. Tensiometer service	15
7.1 Tensiometer refilling	15
7.2 Tensiometer protection	15
7.3 Tensiometer installation	16
7.3.1 Tensiometer replacement without drilling	16
7.3.2 Tensiometer replacement drilling	16
8. Data visualisation	18
8.1 Location details.....	18
8.2 Lysimeter actual data selection graphical.....	19
8.3 Lysimeter actual data numerical.....	20
8.4 Lysimeter data graph	21
9. Appendixes.....	22
9.1 Appendix: Channel specification	22
9.2 Appendix: Lysimeter SAT form (Site Acceptation Test).....	23
9.3 Appendix: Degassing water.....	25
9.4 Appendix: Calculation evaporation/precipitation	26
9.5 Appendix: Channel identification and typical values.....	27
9.6 Appendix: Alert codes channel 24.....	28
9.7 Appendix: Error codes channel 25	28
9.8 Possible precautionary measure	28

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1. Information on this manual

The original instructions for this manual have been written in English. Other language versions of this manual are a translation of the original instructions.



If the text follows a mark (as shown on the left), this means that an important instruction follows.



If the text follows a mark (as shown on the left), this means that an important warning follows relating to danger to the user or damage to the apparatus. The user is always responsible for its own personal protection.

Text

Italic indicated text indicates that the text concerned appears in writing on the display or the apparatus (or must be typed).

2. Introduction

This manual describes the Eijkelkamp Smart Lysimeter operational aspects and user interface communication. This manual covers user service for both moisture controlled as percolating lysimeters.

The Eijkelkamp Smart Lysimeter is an integrated weighing lysimeter concept. It is designed for weighing an isolated soil column and the differences in weight correspond to both evapotranspiration and precipitation.

The **moisture controlled lysimeter** is equipped with a reference tensiometer for measuring the field soil water tension and a moisture suction plate to control the moisture in the lysimeter soil column. A reservoir is used both for active percolation and wetting.

The **percolating lysimeter** passively extracts the surplus of water using a percolation plate into the reservoir.

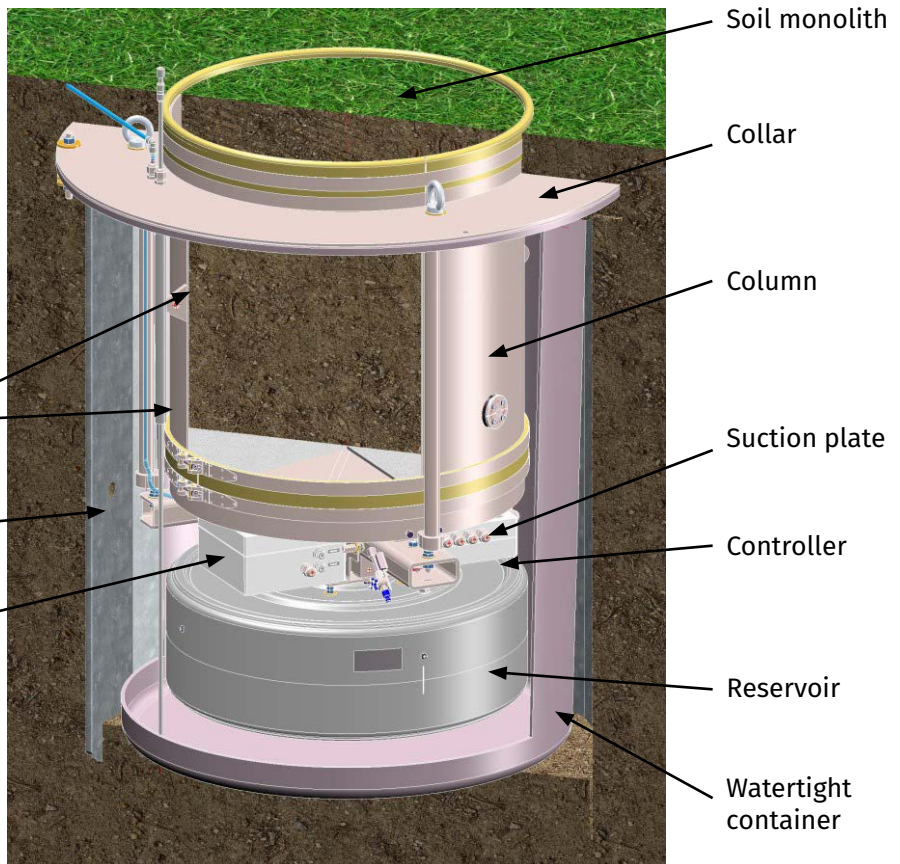
Reference tensiometer



Soil moisture sensors

Sheet piling

Pump box



For both types lysimeters the maximum reservoir water is automatically controlled and emptied.



Every other or further use is not in conformance with the intended use and may affect the warranty. The same applies to unintentional changes to the product.

3. Types and accessories

Eijkelkamp Smart Lysimeter, moisture controlled set

1680 Eijkelkamp Smart Lysimeter, complete set for measuring real evapotranspiration in the field, consisting of a moisture controlled, weighing lysimeter, with field reference tensiometer, sheet piling foundation.
Optional: monolith soil moisture sensors, telemetry, data web portal and solar panel.

Eijkelkamp Smart Lysimeter, percolated set

1681 Eijkelkamp Smart Lysimeter, complete set for measuring real evaporation in the field, consisting of a percolating, weighing lysimeter and sheet piling foundation.
Optional: monolith soil moisture sensors, telemetry, data web portal and solar panel.

Additional accessories

- 1682 Monolith soil moisture sensor set
- 1683 Infrared sensor set lysimeter
- 1684 Lysimeter installation set

4. Technical specifications

Sample	
Sample type	Undisturbed
Sample diameter	50 cm
Sample depth	50 cm
Sample volume	98 L

Mechanical	
Size	ø 83 cm H 98 cm
Weight	100 kg
Product material	RVS 304*, plastics, galvanised steel

General	
Measured parameters	Evaporation, rain
Measuring principles	Weighing
Measuring accuracy	0,1 mm evap/rain
Reading accuracy	0,01 mm evap/rain
Maximum force	300 kg
Power supply	Battery/solar
Voltage	12 volt
Data transfer	SDI-12 / USB
Data plug type	M12 circular 4pole male / USB
Waterproof connection	Yes
Type of registration	Telemetric / SDI-12 logger
Programming possibility	Yes
Number of channels	25
Frequency of registration	5 sec...15 min
Alarm type	Software

* Applicable under normal conditions. Contact your supplier about the possibilities for application e.g. in a saline environment.

5. Safety instructions



For extended service i.e. inspection, special maintenance, repair activities; disassembling and lifting the lysimeter, qualified and experienced staff is demanded. Royal Eijkelkamp provides training for safe and efficient lysimeter installation and service.

For information with respect to specific adjustments, installation, maintenance or repair jobs, which fall beyond the scope of this manual, contact your supplier.



Make sure you have the following data at hand:

Product code

Date of manufacture

Serial number

Date of purchase

Invoice number



Users/Field workers should have a good physical and mental condition that is consistent with due diligence and duty.

The user should have a general knowledge about the use of a computer system and computer programs. For the basic maintenance work a general technical background is preferred.



The work must be carried out in safe environmental conditions in order to avoid risk of accidents.



Users/Field workers must take into account the environmental and weather conditions and must be equipped with personal protection tools.



Avoid overloading the lysimeter (never stand on/support/etc.). Overloading leads to permanent damage, warranty will expire!

In case of disturbance by human or animals precautions must be taken i.e. signs and fence as precaution to avoid injuries due to lysimeter damage

6. Regular inspection and field maintenance

The interval of field maintenance depends on the individual circumstances. Recommended service interval is 4 times per year.

Extreme weather periods can be a trigger for a field inspection i.e. flooding or draught or temperature both cold and hot.

Data, alarms, etc. from the lysimeter are a good indicator for a need of additional maintenance. Abnormal or sudden changes of measurement values can indicate the need for a service visit. In case of undefined problems please consult your supplier for advice.



During maintenance avoid that the direct environment of the lysimeter is compacted or that the vegetation is trampled.



A properly installed and maintained lysimeter normally has class IP-68 protection (as indication: 10 cm H₂O above ground-level for several days).



The lysimeter and data must be actively managed. Damage caused by inadequate action or temporary being out of operation on location without data being generated are not covered under warranty.

6.1 Typical maintenance actions

1. Checking and refilling the reference tensiometer with degassed water (see Chapter 8.1)
2. In case of leak water in the underground housing it shall be pumped off. At the surface there is a pipe connection to the pump line to the bottom of the housing.



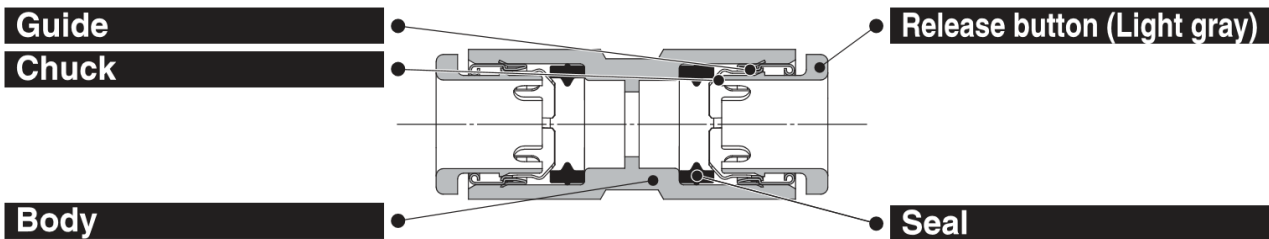
A possible trigger is error code 8 in the measurement data (see: appendix 7.7)



Always check visible components like the silicon collar sealing for damage.



- Release vent plug from straight fitting. Release (chuck collet) button to remove plug.



- Connect an external pump to remove water.
- Replace vent plug in straight fitting. Push the clean plug into the fitting and pull vent plug a little to tighten.



In case of serious amount of water i.e. more than 3 liter a complete leak inspection is advised. Lifting the lysimeter by qualified and experienced staff is to be considered.

3. Checking the pumpbox function of both 'lysimeter pump' as 'reservoir pump' and inspect for leakages i.e. due to wearing of the pumps.



Inspection/ replacement of pumps by qualified and experienced staff only.



Advised pump replacement interval: 250 running hours. Depending on the settings/ field conditions/ etc.



Always avoid long-term continuous pumping. Special attention is required when the pressure plate runs dry.



Always avoid pumping during frost!

4. Inspection of the reservoir pump exhaust tube, located next to pipe connection.



Reservoir pump exhaust tube has to be free of obstacles.

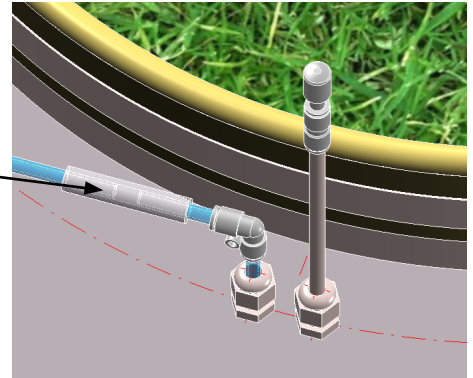


It is advised to connect the rigid hose with a piece of soft silicone hose. In case of an obstacle, the drain hose will come loose so the chance of damage is reduced.

- As the vegetation grows it must be pruned regular, not interfering with the surrounding. Take care that the silicon collar sealing around the lysimeter is not damaged as this will lead to leakage.



There should be no entanglement of vegetation soil sample with vegetation environment!



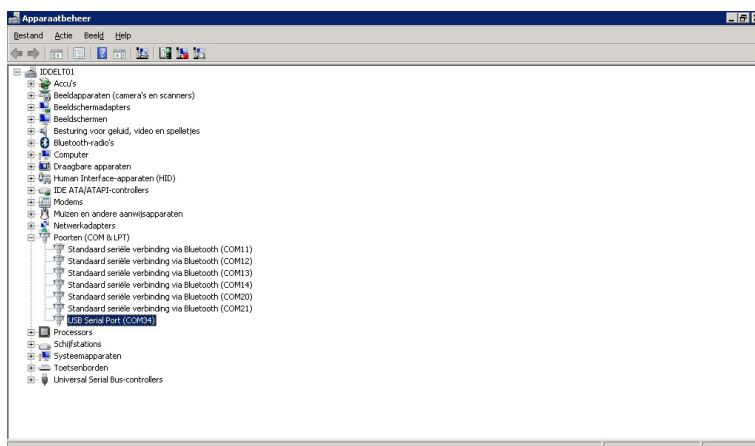
- In case of disturbance by human or animals (like overload; gnawing by pests; etc.) precautions can be taken i.e. signs and fence as precaution. Possible precautionary measure; see appendix 7.8.

6.2 Checking settings and actual values

The Eijkelkamp Smart Lysimeter is equipped with an integrated autonomous controller for measuring and controlling. The controller has 2 communication ports:

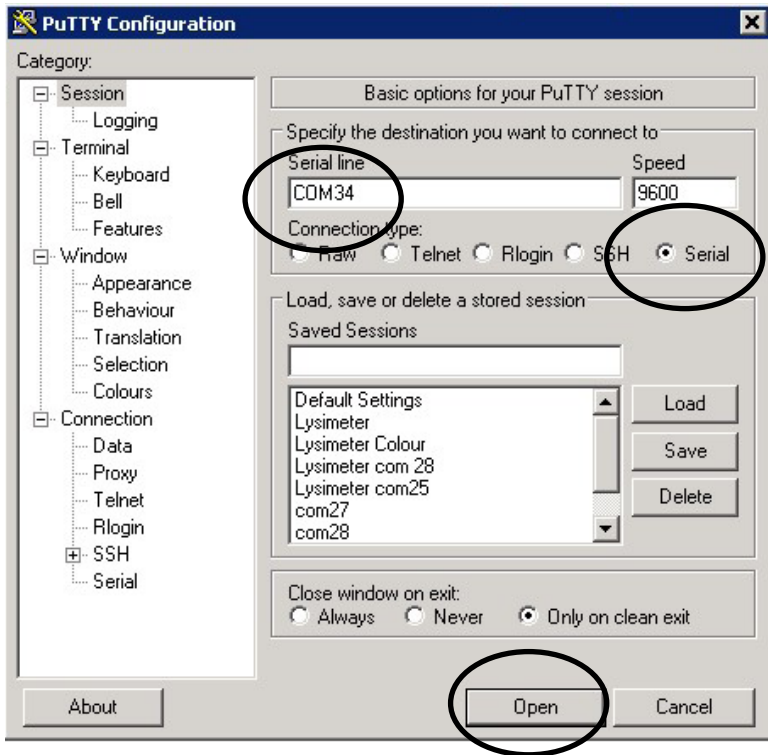
- SDI-12 for communication with dataloggers or modems inclusive the lysimeter power supply,
- USB 2.0 for user communication i.e. a laptop to view data and setting controller parameters

- Make sure that the lysimeter sufficient power supply is available, typically 12 volt DC.
- Connect the lysimeter USB cable to the laptop using an USB hub (due to the 10 meter cable length not supported by newer laptops).
- Check and register the settings and actual values of measurements using the USB connection.
- The proper USB port number can be found using *Windows configuration, Device manager*.



- In Device manager *Ports*(COM&LPT) the recognized USB ports are listed (in this case *USB serial Port 34*).
- Start the communication program PuTTY (free to download 'Telnet-client' or use a similar one).
- Select *Serial mode*.
- Fill in the proper port number (in this case *USB serial Port 34*).

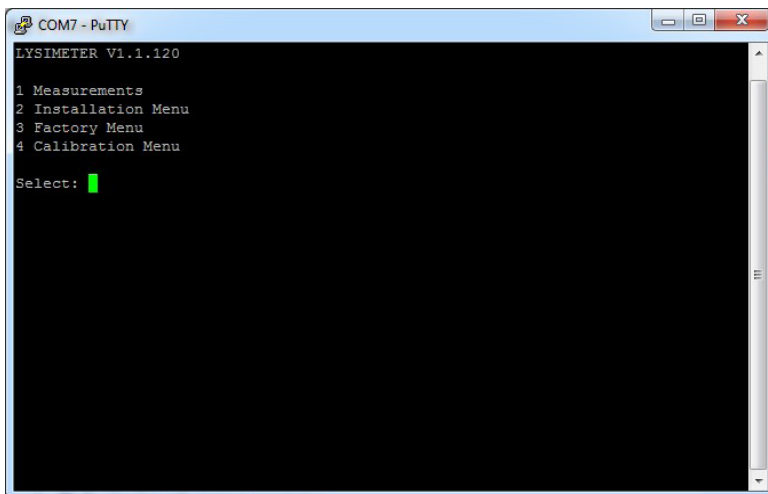
9. Start communicating pressing the *Open* button.



Now the communication screen will open and the lysimeter will start communicating. After some seconds the *Main Menu* will appear:

Booting LYSIMETER

After some seconds the Main Menu will appear...



6.3 Main menu

The Main menu shows the software version and the 4 main menu options:

```
Lysimeter V1.1.xxx

1. Measurements
2. Installation Menu
3. Factory Menu
4. Calibration Menu*

Select: ..
```

* Only available by technician password

6.4 Measurements menu

The measurement menu shows the actual values of the connected sensors.

By selecting option *1 Refresh measurements* the measurement values are refreshed. Option 2 refreshes the measurements automatically where the refresh rate is equal to the measurement interval in the installation menu.

```
MEASUREMENTS

Weight Lysimeter (gram)*           : +191616
Weight Reservoir (gram)*           : +2546
Tensiometer Reference (kPa)         : -3.94
Tensiometer Temperature (C)         : +15.18
Tensiometer Supply Voltage (Vdc)    : +13.0
Tensiometer Filling state           : +0
Pressure Plate (kPa)                : -3.89
Lysimeter Temperature (C)           : +15.7
Soil Moisture Top (E)                : +10.79
Soil Moisture Top Conductivity (dS/m): -9999
Soil Moisture Top Temperature (C)    : +29.4
Soil Moisture Bottom (E)             : +7.92
Soil Moisture Bottom Conductivity (dS/m): -9999
Soil Moisture Bottom Temperature (C) : +18.6
Tensiometer Top (kPa)                : -19.8
Tensiometer Top Temperature (C)      : +29.5
Tensiometer Bottom (kPa)             : -10.7
Tensiometer Bottom Temperature (C)   : +18.8
Pump Time (mS)                       : +0
Supply Voltage (V)                   : +12.96
Current Errors                        : +0
Current Warnings                      : +0

1 Refresh measurements
2 Auto Refresh Measurements           : OFF
0 Return
```

If a parameter value is not displayed the sensor is either not installed or defective.

* The '*Weight Lysimeter*' and '*Weight reservoir*' measurements are integrated by a Gaussian formula using the past 10 measurements. For a fast update of measurements at least 10 measurement refreshments should be performed i.e. performing 10 times option 1. As alternative In the *Factory menu* option *D: Gaussian Enable Status* can be changed to disabled to get an instant update of the measurements. Take care to reset the *Gaussian Status* to enable again after service!

6.5 Installation menu

The installation menu is used for manual operation during installation and service and sensor configuration.



Be careful this can damage the suction plate!

INSTALLATION MENU	
1	SDI-12 Lysimeter address : 0
2	Sample interval (sec) : 300
3	Pump reservoir on threshold (gram) : 18000
4	Pump reservoir off threshold (gram) : 15000
5	Suction plate vacuum : OFF
6	Suction plate pressure (!) : OFF
7	Suction plate regenerate start
8	Reservoir fill : OFF
9	Reservoir empty : OFF
A	Reservoir Autofill : OFF
B	Lysimeter winter protection : ON
C	Lysimeter pump operating hours (h) : 0
D	Reservoir pump operating hours (h) : 0
E	SDI Sensor address configuration

Description of the installation menu options:

1 *SDI-12 Lysimeter address*

This address number is set for the datalogger or modem connected to identify the lysimeter. Default = 0.

2 *Sample interval (sec)*

At every sample interval the lysimeter measures the sensor values, depending on these values the suction plate pump or reservoir pump can be controlled. This is an autonomous control process for the lysimeter.

The minimum sample interval = 10 seconds. In this mode the lysimeter will use more energy due to intensively controlling the pumps. The maximum sample interval is 900 seconds (15 minutes).

If the datalogger or modem request measurement data from the lysimeter automatically a measure and control cycle is initiated. A practical sample interval could be 300 seconds (5 minutes).

Standard a sample and control cycle is initiated by the SDI-12 measurement command from a datalogger or telemetry.

3 *Pump reservoir on threshold (gram)*

As the reservoir has reached this maximum value the reservoir pump will start emptying the reservoir until the off threshold is reached. The maximum reservoir value is 25 liters (25000 gram), a typical upper threshold value is 18000 gram.

4 *Pump reservoir off threshold (gram)*

As the reservoir has reached this minimum value the reservoir pump will stop emptying the reservoir. The typical minimum reservoir value is 15000 gram.

5 *Suction plate vacuum*

This option can be used for testing the suction plate. Pumping will lower the suction plate pressure measured. Do not use this option longer than 10 seconds for testing.

Alternatively this option can also be used for filling the suction plate with degassed water during installation.

6 Suction plate pressure (!)

Pumping will increase the suction plate pressure measured.



Be careful this option can damage the suction plate by overpressure!

Do not use this option longer than 10 seconds for testing(!).

This option can also be used for emptying the suction plate during installation.

7 Suction plate regeneration start

This option is used for filling the suction plate or refilling after a dry period where the suction plate is dried out. The process is that reservoir water is pumped into the suction plate and air is pushed out via the membrane. If the air is pushed out the membrane becomes wetted and closes the air permeability which increases the pressure. This stops the water pumping action and the pump will now create a vacuum to test the suction plate function.

8 Reservoir fill

The reservoir can be filled using this option. The lysimeter exhaust hose is used as supply source.

9 Reservoir empty

The reservoir can be emptied using this option, the lysimeter exhaust hose is used as drain.

A Reservoir Autofill

In dry periods when more water is needed for maintaining, the reservoir can supply the lysimeter. The reservoir can be refilled automatically. Place the reservoir exhaust hose into an extended reservoir. Make sure the supplied water is not contaminated. Remind that the same hose is used for the lysimeter.

B Lysimeter winter protection

During winter time evaporation is minimal, sufficient (solar) power supply can be a problem and damage due to frost can not always be excluded. Therefore a winter mode can be selected where measurements are still performed but pumping is inhibited. This will minimise power consumption and still enables monitoring. Beware that an increment of lysimeter moisture level can arise.

C Lysimeter pump operating hours (h)

The peristaltic lysimeter pump uses pump hoses that in time wear out and can cause leakage in time. Observing the operating hours pump in time replacement can be planned.

D Reservoir pump operating hours (h)

The peristaltic reservoir pump uses pump hoses that in time wear out and can cause leakage in time. Observing the operating hours pump in time replacement can be planned.

E SDI Sensor address configuration

In case of connecting a new SDI-12 sensor i.e. the reference tensiometer. The new sensor should have a SDI-12 address = 0 (mostly default for new sensors). Selecting this option the new sensor is recognized and the user is asked for the function of the new sensor. Select the proper item: Reference Tensiometer. The reference tensiometer will now be recognized and values displayed in the measurement menu.

6.6 Factory menu



Be careful: changing options does effect the lysimeter operation!

FACTORY MENU	
1	Reservoirpump max speed (%) : 100
2	Reservoirpump max time (min) : 15
3	Lysipump max speed (%) : 100
4	Lysipump minimum on time (msec) : 10
5	Lysipump maximum on time (sec) : 5
6	Pump controller PID - Kp : +10.000
7	Pump controller PID - Ki : +0.200
8	Pump controller PID - Kd : +0.200
9	Pump controller PID - Gain : 100
A	Lysipump time direction change in to out (min) : 10
B	Lysipump time direction change out to in (min) : 60
C	Pump enable minimum temperature : +5.0
D	Gaussian Enable Status : DISABLED
E	Datafilter Sigma of Gaussian : 11
F	Extended HMI information : ENABLED
G	SDI12 Terminal
H	Set Settings factory defaults

Description of the options:

1 *Reservoirpump max speed (%)*

Pump maximum speed, default =100.

2 *Reservoirpump max time*

To prevent overloading of the reservoir pump the maximum pump time is set to 15 minutes. As the pump capacity is 0.235 l/min, about 3.5 litre is pumped during a pump session. If more pump time is needed to obtain the requested minimum reservoir weight then multiple pump sessions will be executed.

3 *Lysipump max speed (%)*

Pump maximum speed, default =100.

4 *Lysipump minimum on time (msec)*

The lysimeter pump time is calculated using the difference between tensiometer measurement and suction plate depending on previous pump actions. The minimum pump time is defined. Default is 10 msec.

5 *Lysipump maximum on time (sec)*

The lysimeter pump time is calculated using the difference between tensiometer measurement and suction plate depending on previous pump actions. The maximum pump time is defined. Default is 5 sec. In dry conditions this time might be extended to reach a maximum vacuum. A maximum of 15 seconds or less is recommended. In case of very dry circumstances the suction plate can dry out resulting in air entrance, so the maximum pump on time prevents overpumping.

6 *Pump controller PID – Kp*

The lysimeter pump time is calculated using the difference between tensiometer measurement and suction plate depending on previous pump actions. The calculation is a PID function using the proportional, integration and differential parameters, default : +10.000 (kPa).

7 Pump controller PID - Ki

The lysimeter pump time is calculated using the difference between tensiometer measurement and suction plate depending on previous pump actions. The calculation is a PID function using the proportional, integration and differential parameters, default : +0.200.

8 Pump controller PID - Kd

The lysimeter pump time is calculated using the difference between tensiometer measurement and suction plate depending on previous pump actions. The calculation is a PID function using the proportional, integration and differential parameters, default : +0.200.

9 Pump controller PID - Gain

The lysimeter pump time is calculated using the difference between tensiometer measurement and suction plate depending on previous pump actions. The calculation is a PID function using the proportional, integration and differential parameters. The gain parameter default : 100.

A Lysipump time direction change in to out (min)

After pumping water into the lysimeter the pressure increases, if the pressure is exceeding the requested reference pressure a time-out is forced to prevent overreacting of the control system. Default : 10 minutes.

B Lysipump time direction change out to in (min)

After pumping water out of the lysimeter the pressure decreases, if the pressure is exceeding the requested reference pressure a time-out is forced to prevent overreacting of the control system. Default : 60 minutes.

C Pump enable minimum temperature

To prevent the system to pump when tubes get frozen a minimum pump temperature is chosen. As the temperature is measured at the electronics a higher then surface temperature is chosen. Default 5°C.

D Gaussian Enable Status

As weight is to be measured very secure, several distortions in the signal can be effectively filtered by a gaussian algorithm over a number of measurements. The filter can be enabled or disabled, we do advise to enable the filter. Default : enabled.

E Datafilter Sigma of Gaussian

The filtering of data is over a certain number of past measurements as specified, from these measurements the most upper and lower outlier values are discarded from the calculations. Default: 11 measurements.

F Extended HMI information

Default: ENABLED.

G SDI12 Terminal

H Set Settings factory defaults

Generally sensor signals are integrated by a Gaussian formula using the past 10 measurements. For a fast update of sensor signals at least 10 measurement refreshments should be performed i.e. performing 10 times option 1. The Gaussian parameter is only available for technicians. If for a sensor or parameter no values are displayed the sensor is either not installed or defective.

6.7 Calibration menu

CALIBRATION MENU (* For documentation only)



The calibration menu is available for factory technicians only!

Enter password (ESC cancels): XXXX

```
CALIBRATION MENU
1 Temperature High [ +20.2][ 515]
2 Lysi Weight High Temp High [ 0][ 3191][ 528]
3 Resv Weight High Temp High [ 0][ 3712][ 527]
4 Lysi Weight Low Temp High [ 100][ 490934][ 527]
5 Resv Weight Low Temp High [ 100][ 524287][ 526]
6 Temperature Low [ +5.5][ 427]
7 Lysi Weight High Temp Low [ 0][ 3390][ 528]
8 Resv Weight High Temp Low [ 0][ 4272][ 527]
9 Lysi Weight Low Temp Low [ 100][ 488911][ 527]
A Resv Weight Low Temp Low [ 100][ 524287][ 526]
B Suctionplate Pressure Low [ -99.0][ 231757]
C Suctionplate Pressure High [ +0.0][ 262]
D Get / Set entire calibration
E Set Calibration factory defaults
F SDI12 Lysimeter Serial Number : XXXXXXXX
G Reset pump running hours
H Tensio ref simulated value (hPa, -9999=disable) : -9999.0
0 Return
```

6.8 Dismantle / environment/ disposal of waste



Dismantle by qualified personnel.



Always observe the local rules and regulations with respect to processing or disposing of (non-reusable) parts.



Do not dispose with other types of waste! This could possibly cause harm to the human health or the environment. If worn, damaged or not necessary anymore, please return the modem to your local dealer for correct disposal or repair.

7. Tensiometer service



The moisture controlled lysimeter is equipped with a reference tensiometer for measuring the field soil water tension at a depth of 50 cm beneath the soil surface. It is filled with degassed water and should be refilled regularly. If the soil gets drier than -85 kPa, the tensiometer runs dry and must be refilled as soon as the soil is sufficiently moist again. The tensiometer can operate in the temperature range of -30 to + 70°C. It should be protected from direct sunlight to prevent heating errors.

7.1 Tensiometer refilling

The tensiometer can be refilled using the filling tubes, without tensiometer replacement. The use of the filling syringe kit as delivered is advised.

1. Remove the rubber tube from the black marked metal refill tube.
2. Connect the open end rubber tube to a syringe number 1 filled for 3/4 degassed water.
3. Connect the black marked metal tube to the rubber refilling tube at syringe number 2 filled for 1/4 with degassed water.
4. Keep both syringes during the refilling process vertical to prevent air into the tubes. Pull the syringe number 2 plunger to suck the water out of syringe number 1 through the tensiometer to fill it.
5. No air bubbles should appear anymore in syringe number 1 when the tensiometer is filled completely.
6. Disconnect the syringes and reconnect the rubber tube between both metal filling tubes.



7.2 Tensiometer protection

Refilling tubes must be protected from heating up and solar radiation. Preventing expansion of possible air bubbles resulting in a variation of the reading. Therefore, refilling tubes should be thermally protected by providing an insulating protection. Keep a distance of approx. 5 cm to the soil surface to avoid ant population inside the tube.

7.3 Tensiometer installation

- Plastic bottle protecting the ceramic cup (must be filled to half with water to keep the cup wet).
- Do not leave the cup in air for more than 5 minutes as tensiometer water will evaporate and the tensiometer will need to be refilled.
- Ceramic cup: Do not touch the cup with your fingers. Grease, sweat or soap residues will influence the ceramic's hydrophilic performance.
- Excess pressure: The maximum non destructive pressure is 300 kPa. Higher pressure, which might occur for example during insertion in wet clayey soils or during refilling will destroy the pressure sensor!
- Frost: Tensiometers are filled with water and therefore are sensitive to frost! Protect tensiometers from frost at any time. Tensiometers normally are not damaged when the cup is installed in a frost free soil horizon (in general below 20 cm).
- Keep the cable connector clean and dry i.e. using a plastic bag.
- Cables are preferable buried in the soil using a protective sleeve or tubing.

The tensiometer can be replaced in case of failure. The watertight screwable M12 cable connector connects the tensiometer to the lysimeter.

The reference tensiometer atmospheric air pressure is conducted to the pressure transducer via the air permeable (white) Teflon membrane and through the cable. The membrane does not absorb water. Water will not pass through the membrane into the cable, but condensed water inside the cable will leave the cable through the membrane.



The white membrane on the cable must always have contact to air and should never be submerged into water.

7.3.1 Tensiometer replacement without drilling

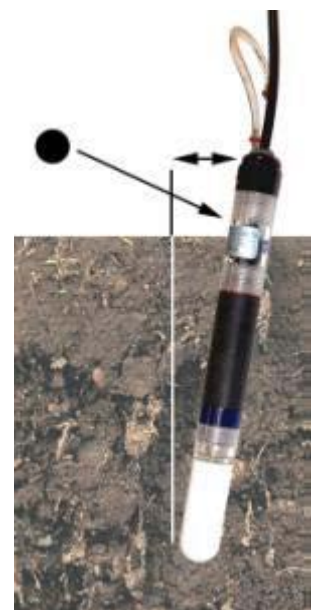
If possible make use of the previous drilled tensiometer hole. Take care inserting the new tensiometer specially in loamy, clayey soils a high pressure can occur just by inserting it into the borehole.

To prevent overpressure the insertion should be very slowly with the rubber refill tubing removed. The tensiometer needs to be refilled after the installation as described in chapter 7.1.

7.3.2 Tensiometer replacement drilling

An installation position would be ideal if the typical water flow is not disturbed by the tensiometer. No preferential water flow along the shaft should be created. Water will not run along the shaft if the tensiometer is installed in an angle because the water will drain into the soil before it reaches the cup and ideal for the optimal removal of air from the cup.

1. Drill the borehole for a length of 73 cm at an angle of 45° resulting in the reference depth of 50 cm. Mark the required drilling depth on the auger and on the tensiometer shaft.



2. Slurrying the cup is only recommendable in clayey soils and only if the bore hole is larger than 24 mm. In coarse sand or pebbly soils fine pored slurry might create a water reservoir which slows down the response.
3. Take off the protective plastic bottle from the tensiometer cup. Tilt and pull the bottle off carefully. The yellow sticker with the dot on the shaft's top end that marks the position of the exit opening of the external filling must exactly face up!
4. Insert the tensiometer into the hole to the depth mark without using force, if you feel a light resistance at the last few cm indicating proper soil contact of the ceramic.



Do not use any force. Do not hit the tensiometer - this may damage cup and pressure sensor.

5. In clayey soils a dangerous overpressure might develop. To prevent overpressure the insertion should be very slowly with the rubber refill tubing removed. The tensiometer has to be refilled after the installation as described in chapter 7.1
6. Press the soil surface gently to the shaft to close the gap.
7. Push the shaft water retaining disk down to cover the soil surface. This prevents water from running down into the borehole along the shaft.
8. Connect the signal cables to the lysimeter
9. Slide the supplied thermal insulation tube over the shaft end and the refilling tubes. Bend the signal cable and lead it back through the thermal tube.
10. Protect the cables against rodent bites. Lead the cables through plastic pipes or use the plastic protection tubes.



8. Data visualisation

Using the Eijkelkamp telemetry and web portal lysimeter evapotranspiration, precipitation and sensor values can be visualized. Also various other sensors as meteorological stations, soil moisture profile sensors, surface and groundwater quality and quantity data can be displayed.



8.1 Location details

Static characteristics

LOCATION	
Code	LYSI_01
Description	Eijkelkamp Demotuin ✎
TCN type	ESENSE_LYSIMETER
Active	✖
Type	EV - Evaporation ✎
Coordinates - WGS84	51.98834 × 6.0536 ✎

CONNECTION	
Id	34505506
Type	48 - esense backoffice
Modem	esense.modem.34505506
Application	Webscada, esense_backoffice, noconnect - no connection

[Save table as CSV](#)



[Google maps](#) [Google streetview](#)

Templates

Assigned templates:
no templates assigned

Assign template:

[Manage templates](#)

8.2 Lysimeter actual data selection graphical

Last contact
2018-06-28 09:00:52

Evaporation

System properties

Modem battery **100.0 %**
 Logger battery **100.0 %**
 Signal strength **-67 dBm**

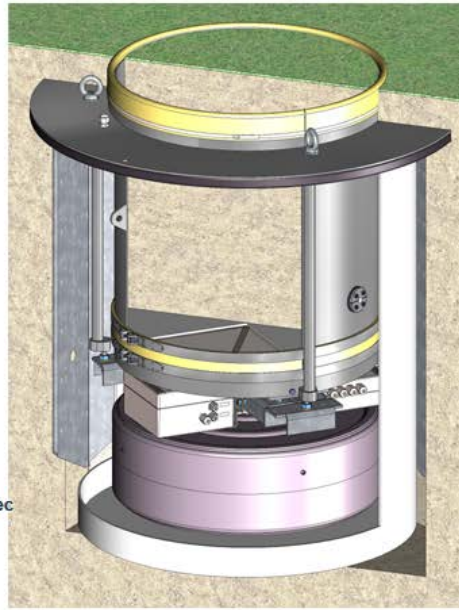
Evaporation last hour **0.2 mm**

Weight Lysimeter **163,019.0 g**

Tensiometer reference **-68.3 kPa**
 Tensiometer temperature **17.2 °C**

Pressure plate **-58.8 kPa**
 Lysimeter pump **-5,476.0 msec**

Weight Reservoir **12,476.0 g**



Ground level *-370 cmNAP*

Most recent value

163.019,0 g
 2018-06-28 08:50

Soilmoisture top **10.8 ε**
 Tensiometer top **-1,217.6 kPa**

Soilmoisture bottom **9.2 ε**
 Tensiometer bottom **-2,884.7 kPa**

Lysimeter supply voltage **13.5 V**
 Lysimeter Temperature **18.0 °C**

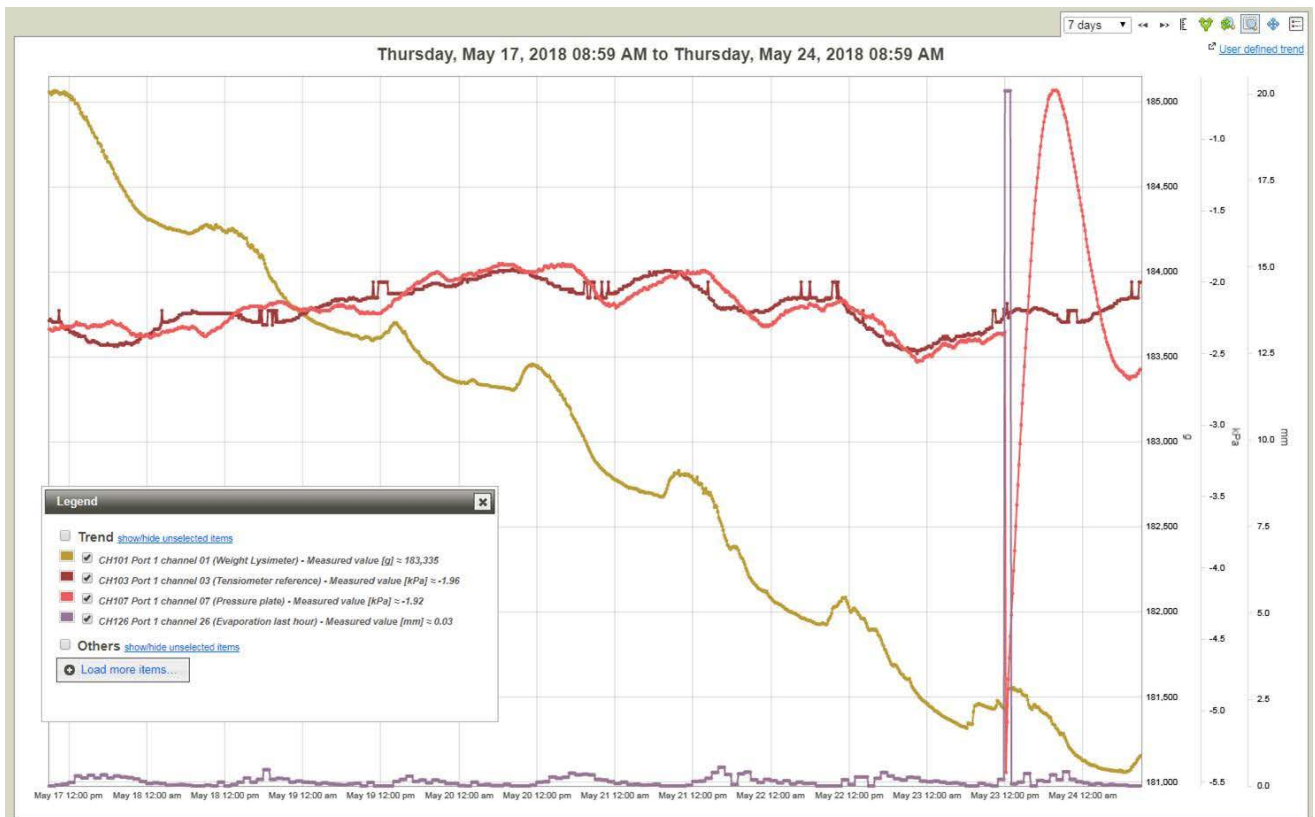
8.3 Lysimeter actual data numerical

All lysimeter sensor channels are displayed.

Sensor ports		
Port 1 Type	Description	Current value
	SDI-12 ESW LYSI 1. <u>XXXXXXXXXX</u>	
Channel 1	Port 1 channel 01 (Weight Lysimeter)	163,019 g
Channel 2	Port 1 channel 02 (Weight Reservoir)	12,476 g
Channel 3	Port 1 channel 03 (Tensiometer reference)	-68 kPa
Channel 4	Port 1 channel 04 (Tensiometer temperature)	17.2 °C
Channel 5	Port 1 channel 05 (Tensiometer supply voltage)	13.6 V
Channel 6	Port 1 channel 06 (Tensiometer filling state)	0
Channel 7	Port 1 channel 07 (Pressure plate)	-59 kPa
Channel 8	Port 1 channel 08 (Lysimeter Temperature)	18.0 °C
Channel 9	Port 1 channel 09 (Soilmoisture top)	11 ε
Channel 10	Port 1 channel 10 (Soilmoisture top conductivity)	-9,999 dS·m ⁻³
Channel 11	Port 1 channel 11 (Soilmoisture top temperature)	19.1 °C
Channel 12	Port 1 channel 12 (Soilmoisture bottom)	9 ε
Channel 13	Port 1 channel 13 (Soilmoisture bottom conductivity)	-9,999 dS·m ⁻³
Channel 14	Port 1 channel 14 (Soilmoisture bottom temperature)	19.1 °C
Channel 15	Port 1 channel 15 (Tensiometer top)	-1,218 kPa
Channel 16	Port 1 channel 16 (Tensiometer top temperature)	18.9 °C
Channel 17	Port 1 channel 17 (Tensiometer bottom)	-2,885 kPa
Channel 18	Port 1 channel 18 (Tensiometer bottom temperature)	18.8 °C
Channel 19	Port 1 channel 19 (Lysimeter pump)	-5,885 msec
Channel 20	Port 1 channel 20 (Reservoir pump)	0
Channel 21	Port 1 channel 21 (Lysimeter supply voltage)	13.5 V
Channel 22	Port 1 channel 22 (Info 1)	-9,999
Channel 23	Port 1 channel 23 (Info 2)	30
Channel 24	Port 1 channel 24 (Alert)	12 code
Channel 25	Port 1 channel 25 (Error)	0 code
Channel 26	Port 1 channel 26 (Evaporation last hour)	0.2 mm
Channel 27	Port 1 channel 27 (Reserve 1)	0
Channel 28	Port 1 channel 28 (Reserve 2)	???
Channel 29	Port 1 channel 29 (Precipitation last hour)	0.0 mm
Channel 30	Port 1 channel 30 (Reserve 3)	0
Channel 31	Port 1 channel 31 (Reserve 4)	???

8.4 Lysimeter data graph

All lysimeter sensor channels can be displayed in graphs: user selectable channels, periods, scaling and zoom options.



Typical view for 2 dry days in spring
Tensiometer value (red)
Lysimeter weight (yellow)
Evaporation (purple)

9. Appendixes

9.1 Appendix: Channel specification

Receiving data by the backoffice portal the following identification is used.

Channel	Lysimeter channel name
1	Weight lysimeter (g)
2	Weight reservoir (g)
3	Tensiometer reference (kPa)
4	Tensiometer temperature (°C)
5	Tensiometer supply voltage (V)
6	Tensiometer filling state (0/1 = air)
7	Pressure plate (kPa)
8	Lysimeter temperature (°C)
9	Soil moisture top (e')
10	Soil moisture top conductivity (dS.m ⁻³)
11	Soil moisture top temperature (°C)
12	Soil moisture bottom (e')
13	Soil moisture bottom conductivity (dS.m ⁻³)
14	Soil moisture bottom temperature (°C)
15	Tensiometer top (kPa)
16	Tensiometer top temperature (°C)
17	Tensiometer bottom (kPa)
18	Tensiometer bottom temperature (°C)
19	Lysimeter pump (msec)
20	Reservoir pump (-1 = empty, 0 = off and 1 = fill)
21	Lysimeter supply voltage (V)
22	Info1
23	Info2 (pump hours lysimeter)
24	Alert (code)
25	Error (code)
26	Evaporation last hour netto (mm)*
27	Evaporation last hour individual (mm)**
28	Reserve2
29	Precipitation last hour netto (mm)*
30	Precipitation last hour individual (mm)**
31	Reserve4

} Added by Back-Office

* Evaporation last hour netto (mm) Channel 26 and Precipitation last hour netto Channel 29 are calculated values. For each hour the increase and decrease of weight of both lysimeter and reservoir are evaluated against each other and calculated for mm evaporation and rain using the lysimeter surface area.

** Channel 27 and 30 are calculated values. For each hour the increase and decrease of weight of both lysimeter and reservoir are individual incremental calculated mm evaporation and rain using the lysimeter surface area.

See also Appendix Calculation evaporation/precipitation for detailed calculation information.

9.2 Appendix: Lysimeter SAT form (Site Acceptation Test)

Customer		Project	
Serial no. lysimeter		Description	

Functionality test			
No.	Item	Value	Acc.
1	FAT report, calibration report, documentation		
2	Physical installation		
3	Power supply		
4	USB communication		
5	Weight soil monolith		
6	Weight water reservoir		
7	Reference tensiometer		
8	Soil moisture top sensor		
9	Soil moisture bottom sensor		
10	Tensiometer top sensor		
11	Tensiometer bottom sensor		
12	Suction plate pump function	Value = (pump vacuum 10 sec.) value =	
13	Reservoir pump function	value = (pump 30 sec.) value =	
14	Lysimeter operational moisture controlling	(@Sample Interval 30 sec)	
15	User specific settings		
16	SDI-12 communication	test box/ Custom / GDTm	
17	Backoffice communication	3 messages	
18	Site finish		

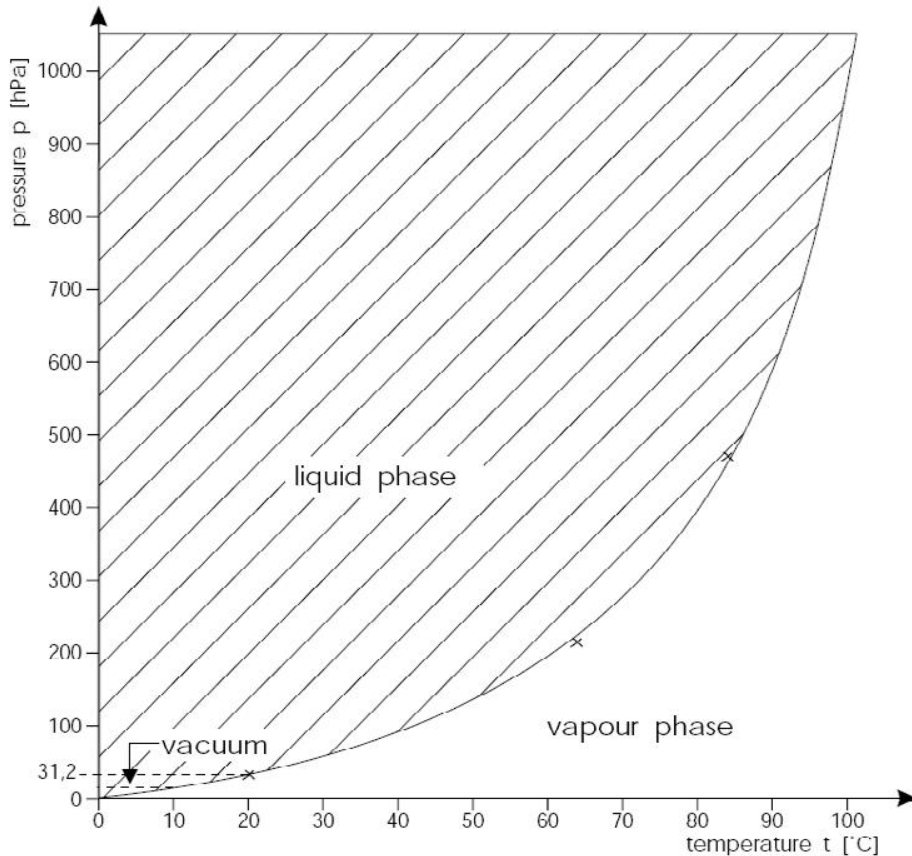
	Configuration		Acc.
PID Kp	5 (clay)	0.5 (Sand)	
PID Ki	0.7 (clay)	0.5 (Sand)	
PID Kd	0.2 (clay)	0.2 (Sand)	
Gaussian	On		
Pump res on threshold	20 000		
Pump res off threshold	15 000		
Lysipump in-out	10 min		
Lysipump out-in	60 min		
Lysipump max on	20 sec		

Remarks

Checked	Date:		Signature
Project leader ESW	Name/Initials		
Customer approval	Name/initials		

9.3 Appendix: Degassing water

Tensiometers should be filled with demineralized or distilled water. This water must be degassed. The tensiometer water limits the measuring range, as can be seen from the two-phase diagram for water and water vapour.



If the ceramic cup is completely dry, first put the ceramic cup into a beaker filled with the degassed deionized water for at least 1 hour to enable the ceramic to get saturated with water. The whole of the ceramic should be below the water level! Do not fill water into the ceramic cup as there is a danger of trapping of air in the ceramic. If the tensiometer contains dissolved gases, the vapour point is raised, which restricts the measuring range considerably. Therefore care should be taken to degas the deionized water as completely as possible (e.g. by boiling). To degas, boil water for 5 minutes, then fill a suitable heat resistant container completely without air, seal tightly and place in a refrigerator to cool.

An alternative method of de-gassing water is to heat the water to boiling, and then pull a vacuum for 15 minutes. Without heating the vacuum process takes 4 hours or more. During vacuum inductive steering or ultra-sonic stimulates the process.

9.4 Appendix: Calculation evaporation/precipitation

Detailed explanation of the evaporation/precipitation calculation:

The sum of lysimeter weight and reservoir weight is used to calculate evaporation and precipitation. As water can be pumped either from lysimeter to reservoir or opposite during lysimeter moisture control both need to be used in calculations.

Evaporation net calculation:

Evaporation = weight difference decrease / lysimeter surface

Weight difference: Within every hour all lysimeter weight and reservoir weight measurements from t1 to t60 for are summed, total net difference is calculated, net weight decrease is assumed as evaporation

Lysimeter surface = 1962.5 cm²

0.1 mm evaporation/m² = 19.63 gram weight decrease

Precipitation net calculation:

Precipitation = weight difference increase / lysimeter surface

Weight difference: Within every hour all lysimeter weight and reservoir weight measurements from t1 to t60 for are summed, total net difference is calculated, net increase is assumed as precipitation

Lysimeter precipitation surface = 2074.4 cm²; including half area silicon rim surface

0.1 mm precipitation/m² = 20.74 gram weight increase

A measurement interval 5 minutes is recommended to evaluate at least 12 measurements each hour. Setting of Gaussian ON is recommended for optimal data filtering i.e. to correct for wind influences.

In case the reservoir reaches the maximum water fill level, the reservoir is pumped of automatically causing a lower reservoir weight. During the pumping of the reservoir, the lysimeter pump is inhibited. Normally the sum of both lysimeter weight and reservoir weight are used to calculate evaporation and precipitation. During this pumping action the calculations for evapotranspiration and precipitation are based only on the lysimeter weight. The difference in reservoir weight before and after the pumping action is not considered in the evapotranspiration and precipitation calculation. In this way the calculations are also correct during pumping actions.

9.5 Appendix: Channel identification and typical values

Channel	Lysimeter channel name	Typical min.	Typical max.
1	Weight lysimeter (g)	150000	250000
2	Weight reservoir (g)	0	24000
3	Tensiometer reference (kPa)	-90	7
4	Tensiometer temperature (°C)	-10	30
5	Tensiometer supply voltage (V)	9	16
6	Tensiometer filling state (0/1 = air)	0	1
7	Pressure plate (kPa)	-85	7
8	Lysimeter temperature (°C)	-10	30
9	Soil moisture top (e')	1	75
10	Soil moisture top conductivity (dS.m ⁻³)	0	20
11	Soil moisture top temperature (°C)	-10	30
12	Soil moisture bottom (e')	1	75
13	Soil moisture bottom conductivity (dS.m ⁻³)	0	20
14	Soil moisture bottom temperature (°C)	-10	30
15	Tensiometer top (kPa)	-10000	-1
16	Tensiometer top temperature (°C)	-10	30
17	Tensiometer bottom (kPa)	-10000	-1
18	Tensiometer bottom temperature (°C)	-10	30
19	Lysimeter pump (msec)	0	10000
20	Reservoir pump (-1 = empty, 0 = off and 1 = fill)	-1	1
21	Lysimeter supply voltage (V)	9	16
22	Info1	-	-
23	Lysimeter pump running hours	0	99999
24	Alert (code)	-	-
25	Error (code)	-	-
26	Evaporation last hour netto (mm)	0	2
27	Evaporation last hour individual (mm)	0	2
28	Reserve2	-	-
29	Precipitation last hour netto (mm)	0	20
30	Precipitation last hour individual (mm)	0	20
31	Reserve4	-	-

9.6 Appendix: Alert codes channel 24

Alert	Description
Alert 1	Tensiometer reference value >4 kPa (groundwater level is all most (-10 cm) at surface
Alert 2	Tensiometer reference value >4.5 kPa (groundwater level is almost (-5 cm) at surface
Alert 4	Reference tensiometer suction plate is lower then -50 kPa
Alert 8	Difference between reference tensiometer and suction plate is more than 10 kPa
Alert 16	Reservoir weight low
Alert 256	Temperature lower then "Pump enable minimum temperature" setting
Alert 512	Power supply low (<10.5V)

9.7 Appendix: Error codes channel 25

Alert	Description
Error 1	Reservoir weight is over 21000 gram
Error 2	Reservoir weight is 500 gram over relative max. reservoir setting
Error 4	Reservoir weight is not lowering during reservoir pump pumping out (-1)
Error 8	Reservoir weight is decreasing (>15 gram per hour) without reservoir pump is pumping out (-1) reservoir is floating
Error 256	Pump Fault
Error 512	Power supply low (<9.5 V)

9.8 Possible precautionary measure

Lysimeters can be disturbed by grazing or digging animals or vandalism. Especially the lysimeter silicone rim, cables and sensors are vulnerable for this. Also in case of entry by man or animal overload of the lysimeter can occur with possible damage to crop and lysimeter.

Possible options for protection:

1. Marking
 2. Fence wire
 3. Grazing gauze
 4. Ultrasonic deterrence
 5. Animal repellent
 6. Camera monitoring
1. Marking
A sign explaining the setup and purpose of the measurements, companioned with a warning not to disturb the site, might help to prevent possible damage caused by visitors.
 2. Fence wire
The placing of a fence wire is effective against larger animals such as deer, reed, swine, sheep, etc. Ensure the correct shielding height of wires or grating and follow the instructions for this, placing warning marking is mandatory.

3. Grazing fence

Fine meshed fence can defend against mice and smaller rodents, the mesh should be at least 40 cm high and be dug in the soil for at least 10 cm.

4. Ultrasonic deterrence

Ultrasound deterrence is effective to keep pests outside the plot area. Underground sounding can also keep the moles at a distance. The intermittent sounds in a frequency that annoys specific pests.

5. Animal repellent

Antiviral agent is a means that can be applied selectively to the silicone edge of the lysimeter and the sensor cables with a brush.

6. Camera monitoring

With a wild camera, high-quality images can be transmitted telemetrically triggered by time interval and / or infrared detection of human and animal.

The pictures enable a plot view in case of disturbance and views through all the season without visiting the plot.